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ABSTRACT

Cross-lagged panel analysis was used to determine the causal relationship between arithmetic progress and two factors (concrete operational development and visuo-spatial figurative ability) in 28 learning disabled boys (9-12 years old). Results of seven operational tasks, five figurative tests, and a diagnostic arithmetic test administered early and late in the year indicated that concrete operational level early in the year predicted arithmetic progress during the year. Figurative ability early in the year was not causally related to arithmetic progress. Findings suggested that fostering the development of concrete operational skills may constitute an effective form of intervention. (CL)

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Concrete Operational Development and Arithmetic Progress in Learning Disabled Boys: A Cross-Lagged Panel Analysis

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Paper presented at the Annual Meeting of the Eastern Psychological Association, Washington, D.C. March, 1978.

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Abstract

Cross-lagged panel analysis was used to determine the causal relationship between arithmetic progress and 1) concrete operational development, and 2) figurative (visuo-spatial) ability. Subjects were 28 learning disabled boys ranging in age from 9 to 12. Seven operational tasks, five figurative tests and a diagnostic arithmetic test were each individually administered both early and late in an academic year. Results indicated that concrete operational level early in the year predicted arithmetic progress during the year. By contrast, figurative ability early in the year, although related to simultaneous arithmetic level, was not causally related to arithmetic progress. Implications for planning remedial education and intervention programs are discussed.

Concrete operational development and arithmetic progress in learning disabled boys: A cross-lagged panel analysis

Children with learning disabilities are not a homogenous group; rather, "learning disability" is defined by exclusion. Any child whose poor academic progress cannot be attributed to low IQ, to emotional disturbance, to environmental disadvantage or to motor or sensory handicap is considered learning disabled. Most research efforts have focused on reading disorders whereas, by comparison, there is very little research related specifically to arithmetic performance in learning disabled children.

Piaget's theory of cognitive development provides an excellent model from which to approach questions about cognitive abilities and progress in arithmetic. Several studies, principally with normal children, have found relationships between arithmetic achievement and performance on a variety of concrete operational tasks (e.g., Dimitrovsky and Almy, 1975; Hood, 1962; Melnick, Bernstein & Lehrer, 1974). In the current investigation we extended this approach to a learning disabled population and examined the contribution of two broad areas of cognitive functioning elaborated by Piaget: figurative and operative thought. Figurative thought, i.e., the direct apprehension of information, includes many cognitive areas already linked to learning disabilities: visual perception, visual imagery and graphic imitation. Concrete operational thought, i.e., the mental transformation of figurative thought, includes abilities often thought necessary to elementary arithmetic: conservation, classification and seriation.

Research does indicate that learning disabled children particularly those with arithmetic disabilities, do not succeed at concrete operational tasks at

the ages that would be expected given their normal intelligence (Stamback, Heriteau, Auzias, Berges, & Ajuriguerra, 1964; Krakow, 1978). And other research has shown that visual perception, visual imagery and graphic imitation are correlated with arithmetic performance among learning disabled children (e.g., McLeod, 1976; Rourke & Finlayson, 1977).

The aim of the present study was to compare the relative effectiveness of these two broad areas of cognitive functioning as predictors of arithmetic achievement in learning disabled boys. Specifically, a cross-lagged panel design was selected to determine if these cognitive measures (at Time 1) could forecast level of mathematical achievement (at Time 2) more accurately than mathematical achievement (at Time 1) predicted later cognitive functioning (Time 2).

Method

Subjects Twenty-eight boys attending a private school for children with normal intelligence and emotional adjustment but with verified learning disabilities participated in this study. They ranged in age from 9-1 to 12-6 at the beginning of the study, and had a mean WISC-R full scale IQ of 104.4 (SD = 9.9). On the average their reading level was two years below expected grade level as measured by the Gray's Oral Reading Test.

Procedure Three types of data (operational, figurative, arithmetic achievement) were collected from each subject both in October and in May of the 1976-77 academic year. This longitudinal design enabled computation and comparison of cross-lagged correlations between operational or figurative level and arithmetic achievement at two points in time. Thus, it was possible to determine if earlier levels of operational or figurative development better predicted subsequent arithmetic achievement than the reverse, i.e., predicting later operational or figurative levels from earlier arithmetic achievement.

The figurative tasks chosen were appropriate for diagnostic use with children in this age range and reliable. They included two subtests of the Developmental Test of Visual Perception (Frostig; 1964); Position in Space, and Spatial Relations; the Detroit Test of Learning Aptitudes Dissarranged Pictures Subtest (Baker & Leland, 1959), the Developmental Test of Visual Motor Integration (Beery & Buktenica, 1967) and the rotation of a square visual imagery task (Piaget & Inhelder, 1971).

The operational tasks chosen had previously correlated with arithmetic achievement (Krakow, 1978). In addition, research indicated that most normal children over age eight succeeded on them, and that each was relatively independent of verbal ability (Sigel & Hooper, 1968). The clinical interview method requiring judgments and explanations was used. The tasks included conservation of number, area, substance and volume; Laurendeau and Pinard's (1970) task involving concepts of left and right; matrix classification, attribute sorting; and ordinal correspondence, in which the child was required to establish correct ordinal pairings between two seriated groups of objects.

Arithmetic level was assessed with the Key Math Diagnostic Arithmetic Test (Connolly, Nachtman & Pritchett, 1974), a non-reading, individually administered test standardized for grades one through six, with grade equivalents up to 9.5.

All standardized measures were scored according to manual directions. Other measures were scored on an ordinal scale ranging from preoperational to fully operational.

Results and Discussion

The mean arithmetic grade level was 4.6 (SD = 1.16) early in the year and 5.9 (SD = 1.49) late in the year. The operational scores ranged from preoperational to fully operational. Figurative scores ranged from age equivalents under five years to fifteen years.

To determine the relationship between perceptual-figurative performance and arithmetic progress over the school year a cross-lagged panel was constructed with correlations between a composite figurative score and KeyMath raw scores. The composite measure of figurative performance was computed by transforming raw scores on the five individual visual-spatial tests to z-scores, weighting each of those z-scores by its loading on the first principal component of a principal components analysis, and finally summing the weighted z-scores. As Figure 1 shows, the cross-lagged correlation between the perceptual-figurative composite in the fall and the KeyMath score in the spring was .54. The corresponding cross-lagged correlation between the KeyMath score in the fall and the perceptual-figurative composite in the spring was .57. There was no significant difference between these two correlations. Thus, no causal relation could be inferred between figurative thought and arithmetic learning.

In addition, this general finding was supported by cross-lagged correlations between each of the five individual figurative measures and KeyMath scores. None of the cross-lagged correlations was significantly different from its corresponding correlation. In fact, there was a non-significant trend for correlations between fall arithmetic level and spring figurative thought to be greater than the corresponding correlations. For instance, Figure 1 reveals that the correlations between fall Key Math scores and spring figurative levels were greater than the corresponding cross-lagged correlations for both the Visual Motor Integration and Frostig Position in Space tests.

Figure 2 shows the cross-lagged panel between the composite operational measures and KeyMath scores. Composite operational scores were computed in the same manner as were composite perceptual-figurative scores. In contrast to the perceptual-figurative results, the correlation (r = .82) between fall

operational level and spring arithmetic level was significantly greater than was the one (r = .66) involving the reverse combination. Moreover, the pattern between the individual operational tasks and arithmetic level was similar to that obtained for the composite operational measure. For instance, Figure 2 also shows cross-lagged results for two measures, attribute sorting and concepts of left and right. In both instances, prior operational level was significantly related to subsequent arithmetic achievement level. Taken together, these findings suggest that concrete operational thought may play a greater causal role in arithmetic achievement than do many traditional measures used in screening and diagnostic programs for learning disabled children. In intervention programs for such children, fostering the development of concrete operational skills may very well constitute an effective form of intervention. Of course, only experimental study, using appropriate treatment and control groups, can provide evidence to support this suggestion. In contrast, from our findings, one cannot assume that arithmetic progress will follow from remediation of visual perceptual deficits. This conclusion runs counter to a great deal of current educational practice in which perceptual programs are used to assist the learning disabled child. Although visual-spatial abilities are clearly related to arithmetic level, it appears that improvements in these perceptual areas follow or co-occur with arithmetic progress.

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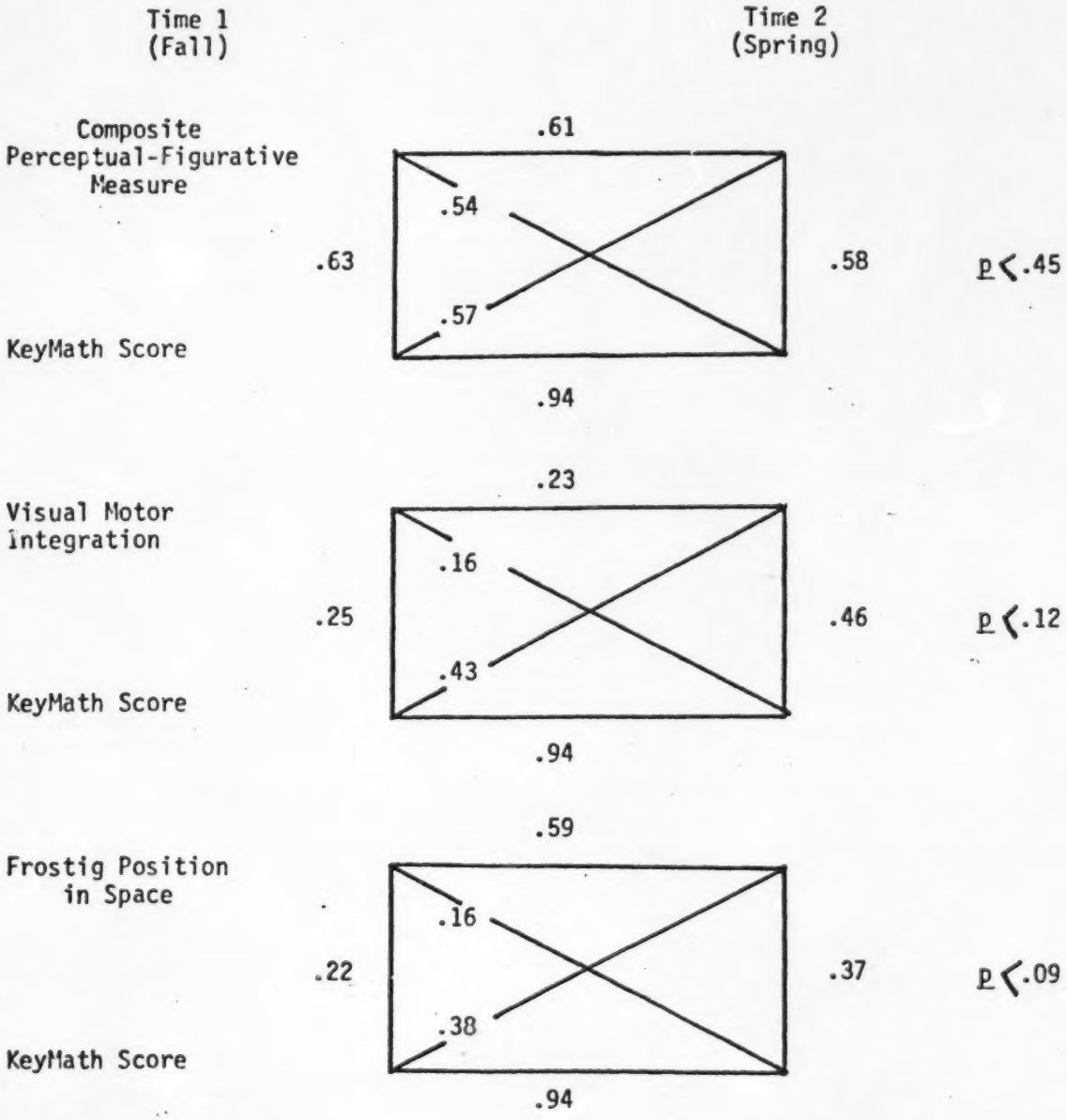
Figure 1

Cross-Lagged Correlations

between Figurative Measures and Arithmetic Levels

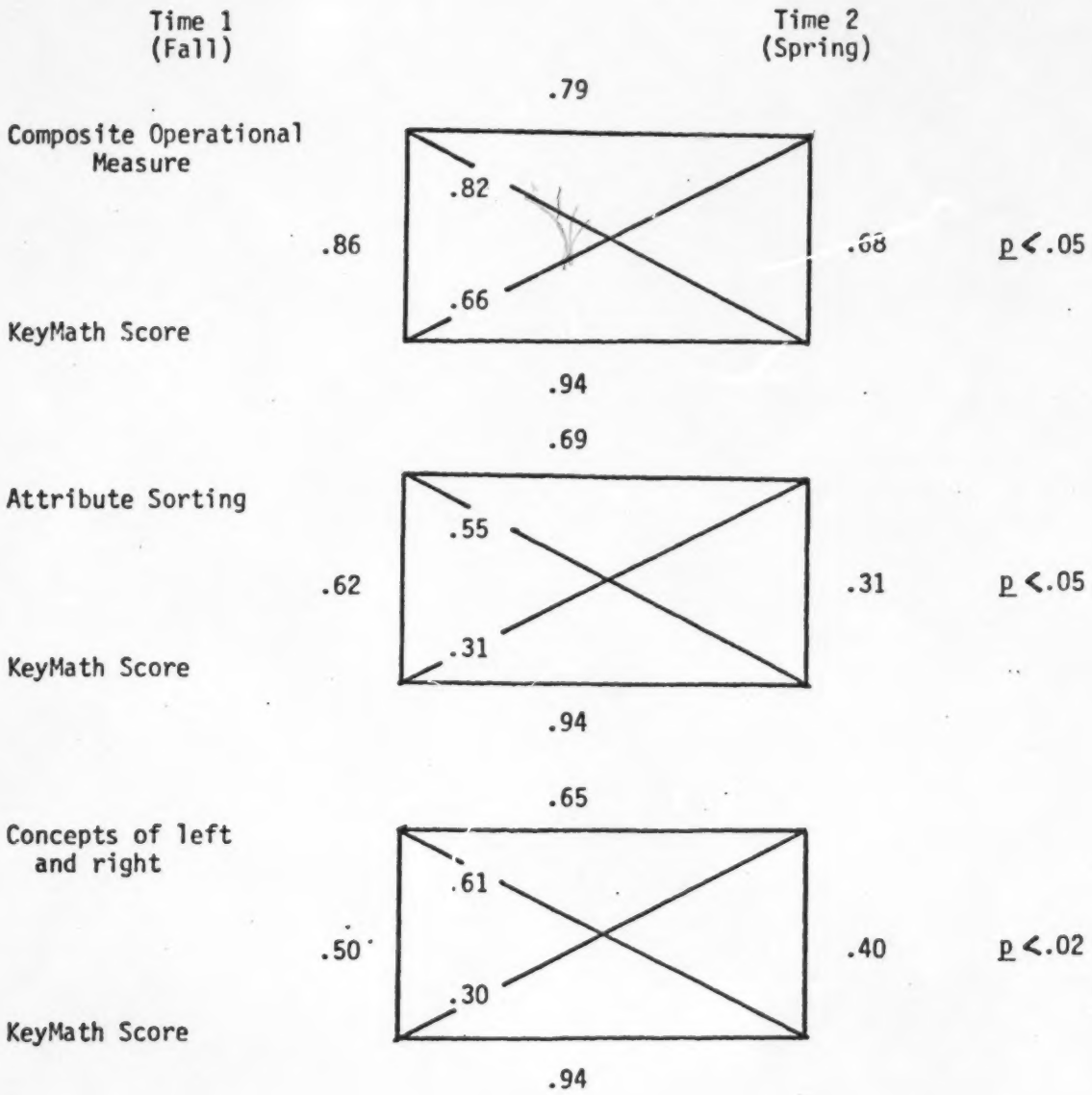


Note. Probability levels are based on the test of the significance of differences between cross-lagged correlations cited by Kenny (1975).

Figure 2

Cross-lagged Correlations

between Operational Measures and Arithmetic Levels



Note. Probability levels are based on the test of the significance of differences between cross-lagged correlations cited by Kenny (1975).